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# MAGNETO-OPTICAL RECORDING AND REPRODUCING DEVICE
[Hikari jiki kiroku saisei sochi]

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Specification

1. Name of this Invention

Magneto-optical Recording and Reproducing Device

2. Claims

[1] Magneto-optical recording and reproducing device for recording and playing back data by providing a small aperture to an optical beam using an optical system, wherein said magneto-optical recording and reproducing device comprises an optical system equipped with a two-dimensional filter capable of selecting a first state of the transmission factor of Gaussian distribution in one way, being constant in the orthogonal direction to the one way, or a second state of the overall constant of the transmission, so that said magneto-optical recording and reproducing device records data by forming a laser spot in an elliptical shape elongated in the right-angled direction to the moving direction of a medium through the two-dimensional filter so as to make the transmission factor with Gaussian distribution in one way, and plays back the data by changing the transmission factor of the two-dimensional filter to be constant all over the area, forming a circular laser spot having the same size diameter as a minor axis of the laser spot at the time of recording.

[2] Magneto-optical recording and reproducing device according to the Claim 1, wherein said two-dimensional filter comprises an electric optical element.

[3] Magneto-optical recording and reproducing device according to the Claim 1, wherein said two-dimensional filter selects said first state or second state by being inserted into or recessed from the optical system.

3. Detailed Explanation of this Invention

[Field of the Invention]

The present invention relates to the improvement of magneto-optical recording and reproducing device operation method (hereinafter, the term "magneto-optical method" will be used) comprising a step of providing a small aperture to a laser beam and irradiating the beam to a recording medium having the orthogonal magnetic recording layer, step of forming small bits (reversal magnetization area) having different optical characteristics by utilizing heat or a reversal magnetic field impressed from an external source, and step of recording data according to existence (or non-existence) of a bit or length of bits, and step of playing back the recorded data by utilizing said different optical characteristics.

[Prior Art]

One example of this type of device is disclosed in Patent No. 61-153858. Figure 3 is a diagram showing the configuration of existing art. In the figure, the reference numeral **1** denotes a disk-shaped magneto-optical recording medium; reference numeral **2** denotes a spindle motor for rotating the medium; reference numeral **3** denotes

a semiconductor laser; reference numeral **4** denotes a laser drive circuit; reference numeral **5** denote a collimator lens; reference numeral **6** denotes a polarization plate; reference numeral **7** denotes a beam splitter; reference numeral **8** denotes a cylindrical lens; reference numeral **9** denotes an object lens; reference numeral **10** denotes an object lens drive system (only the object lens moves up and down); reference numeral **11** denotes an external magnetic field generation means; reference numeral **12** denotes a polarization plate; reference numeral **13** denotes a focus lens; and reference numeral **14** denotes a magneto-optical conversion element. To record data, this existing art shifts the object lens **9** closer to a medium surface to make the lens out of focus and elongates the shape of laser spot in the orthogonal direction of the medium utilizing astigmatism. On the other hand, for playing back the data, the object lens **9** is positioned farther than the recording process to focus the lens so as to change the elongated laser spot to a circular shape (smallest blur circle).

The following explains the reason of requiring the present method.

Prior to the art described above, the laser spot diameter on the recording medium is same for data recording and reproduction. The intensity distribution of laser spot generally forms Gaussian distribution, having higher intensity at the center and lower intensity at the peripheral area. Furthermore, since the temperature

of the outside of laser spot is low, heat tends to escape at the peripheral area of laser spot, thereby not allowing the peripheral area of the laser spot to reach the temperature high enough for recording. As a result, the produced bit information width is shorter than the diameter of the spot as shown in Fig. 4. Subsequently, when the optical system configured for recording is used for reproducing data using the conventional technique, the laser spot having the diameter equal to the recording diameter also irradiates the area other than the produced bit (see Fig. 4). Since the data is played back from a magneto-optical medium by detecting the optical characteristic change (orientation difference of straight polarized light) of the beam having reflected from or transmitted to the area of reversal vertical magnetization, the beam having reflected from or transmitted through the area other than the bit area (i.e., non-reversal area) mixes in the beam having reflected from or transmitted through the bit, forming a noise element, subsequently lowering the CN ratio.

Therefore, the existing art inserts a cylindrical lens to an optical path as shown in Part (a) of Fig. 7. Hence, at the time of recording, a bit information is formed by utilizing the laser spot elliptical shaped at point A or C in Part (b) of Fig. 7. On the other hand, at the time of reproduction, a circularly shaped laser spot at Point B is utilized. The relation between the spot and bit shape is shown in Fig. 11, wherein Part (a) exhibits recording and

Part (b) exhibits reproduction. However, the major axis of circular laser spot at Point B is greater than the minor axis of elliptic laser spot.

[Problems to Be Solved by this Invention]

The drawback of the method described above is that, since the major axis of laser spot at the time of reproduction is not reduced down to the limit of optical system, a signal caused by the beam reflected from, or transmitted through, the area outside bit area is mixed as a noise, hence failing to provide higher CN ratio.

The object of this invention is to improve the CN ratio of reproduction signal by providing a technique that forms an elliptical laser spot elongated in the right- angled direction to the moving direction of the medium at the time of recording, whereas at the time of reproducing, a circular laser spot having the diameter equal to the miner axis of the recording laser spot is provided.

[Method to Solve the Problems]

A density filter that can create a two-dimensional transmission factor distribution (see Parts a, b, and c in Fig. 8) by voltage impression is inserted in the optical path right in front or behind the object lens as shown in Fig. 1, or a filter having said transmission factor distribution, is provided to be inserted to or pulled back from the optical path.

[Operation]

When a focus lens having well adjusted aberration is used, the relation between distribution of electric field amplitude right in front of the lens or converged light and electric field amplitude of focused spot on a focal plane is generally expressed by the following formula:

$$U(p,q) = \iint_A |G(x,y)|\, e^{-\frac{2\pi i}{\lambda}(px+qy)}\, dxdy$$

where U(p, q) denotes the electric field amplitude at coordinate (p, q) on a focal plane; G(x, y) denotes the electric field amplitude at coordinate (x, y) within a plane diagonally crossing the beam right before the focus lens or converged beam.

By assuming that G(x, y) denotes the two-dimensional Gaussian distribution and, also, widely transmitted to the pupil of the lens to the skirts of Gaussian distribution of the beam, the formula described above can form an infinite integration range as shown below:

$$U(p,q) \fallingdotseq \iint_{-\infty}^{\infty} e^{-a^2x^2-b^2y^2}\, e^{-\frac{2\pi i}{\lambda}(px+qy)}\, dxdy$$

By computing this formula, the following result is obtained:

$$U(p,q) \approx \fallingdotseq \frac{\pi}{ab} e^{-\frac{\pi^2}{\lambda^2 a^2} p^2} e^{-\frac{\pi^2}{\lambda^2 b^2} q^2}$$

Therefore, when the intensity distribution of convergent light is axially symmetrical as shown in Part (a) of Fig. 9, the intensity distribution of laser spot on the disk also becomes axially symmetrical as shown in Part (a') of Fig. 9. This technique is utilized by the existing art. However, when a filter having a Gaussian like transmission factor distribution only in one direction (direction of axis y in Fig. 8) (e.g., produced by transmitting an appropriate electric current to an electro chromic element or liquid crystal element) is inserted right in front or behind the object lens to deform the filtered light beam intensity distribution as shown in Part (b) of Fig. 9, the intensity distribution of focus spot becomes as shown in Part (b') of Fig. 9. That is, by applying the direction of axis p in Part (b') of Fig. 9 as the moving direction of the medium, an elliptic focus spot having a major axis in the right-angled direction to the moving direction can be provided.

Also, by uniformly restoring the intensity distribution of optical beam after filtration as shown in Part (a) of Fig. 9, the intensity distribution of focus spot becomes as shown in Part (a') of Fig. 9. The spot diameter at this time becomes the smallest spot

obtainable by this optical system.

[Operational Example]

Figure 1 is a diagram showing an operational example of this invention in which a two-dimensional filter **15** having transmission factor distributed in one direction inserted right in front of an object lens. In the figure, the reference numeral **16** denotes a drive circuit of said two-dimensional filter **15**. Other parts in the figure are same as those in Fig. 3.

Figure 2 is a diagram showing the second operational example using a filter inserted right behind the object lens.

If it is difficult to produce an element that can provide the transmission factor distribution shown in Part (b) in the direction of axis y exhibited in Parts (a), (b), and (c), by integrating numerous small strip filters shown in Part (a) of Fig. 10 can produce the same effect provided by the transmission factor distribution shown in Part (b) of Fig. 10. In this case, each filter individually operated by voltage, only one uniform transmission factor is needed for one element, as long as the transmission factor distribution is similar to the Gaussian distribution in the direction of axis y.

Although the example described above used a two-dimensional filter **15** using an electro optical element such as electro chromic or liquid crystal, the filter configuration is not limited to this method. For example, a two-dimensional filter having a transmission factor providing a fixated Gaussian distribution in one direction may

be inserted in the optical path at the time of recording and pulled out at the time of reproduction.

As explained above, the method based on the present invention passes a light through a two-dimensional filter having a Gaussian-distributed transmission factor in one direction at the time of recording so that the filtered intensity distribution of the cross-sectional area becomes as shown in Part (b) of Fig. 9. As a result, since the intensity distribution of the focus spot is made as shown in Part (b') of Fig. 9, and the moving direction of recording medium is arranged in the direction of axis p in the figure, an elliptical bit having a major axis in the right-angled direction to the moving direction of a medium can be formed.

On the other hand, to reproduce the data, by fixing the transmission factor of the entire area of said two-dimensional filter, the circular focus spot, which is a smallest possible spot creatable by the optical system, can be formed. The spot diameter, in this case, is same as the miner axis of the spot at the time of recording. The relation between the spot and bit information in the configuration is shown in Fig. 6.

[Effectiveness of the Present Invention]

As explained above, the method provided by this invention elongates only the spot diameter in the right-angled direction to the moving direction of the medium at the time of recording and does not enlarge the spot diameter at the time of reproduction. Therefore, a

large recording bit can be formed on the medium without causing deterioration of high frequency recording characteristic.

Furthermore, as the reproduction spot can be sufficiently diminished, the light quantity irradiating outside of the bit information can be reduced, thereby subsequently improving the CN ratio.

4. Simple Explanation of the Drawings

Figure 1 is a diagram showing the first operational example of this invention. Figure 2 is a diagram showing the first operational example of this invention. Figure 3 is a diagram showing the operational example of existing art developed by the inventers of this invention. Figure 4 is a diagram showing the relation between the focus spot and recorded bit information of the existing art. Figure 5 is a diagram showing the relation between the focus spot and recorded bit information of this invention. Figure 6 is a diagram showing the relation between the playback spot and bit information of this invention. Figure 7 is a diagram explaining the theory of the art previously disclosed by the inventers of this invention. Figure 8 is a diagram showing the transmission factor distribution of the filter inserted in the optical path based on this invention. Figure 9 is a diagram showing the intensity distribution of light entering to an object lens or convergence light exiting from the object lens and intensity distribution of focus spot corresponding to those lights. Figure 10 is a diagram showing the filter consisting of

numerous strip-like elements and its transmission factor distribution. Figure 11 is a diagram showing the relation of recording spot, recording pit, and playback spot of the previous art disclosed by the developers of this invention.

1…Magneto-optical recording medium; 2…Spindle motor; 3…Semiconductor laser; 4…Laser drive circuit; 5…Collimator lens; 6…Polarization plate; 7…Beam splitter; 8…Cylindrical lens; 9…Object lens; 10…Object lens drive system; 11…External magnetic field generation means; 12…Polarization plate; 13…Focus lens; 14…Magneto-optical conversion element; 15…Electro chromic element or liquid crystal element; 16…Drive circuit of electro chromic element or liquid crystal element.

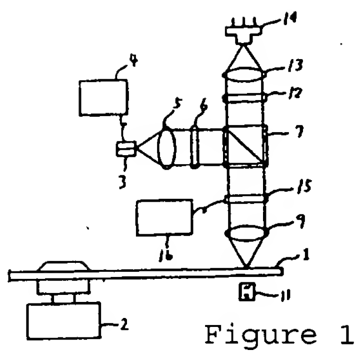

Figure 1

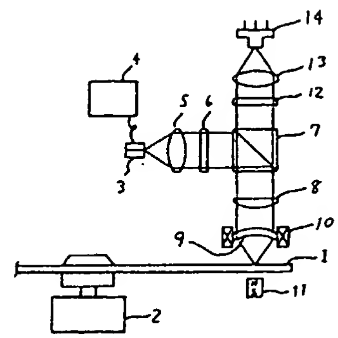

Figure 3

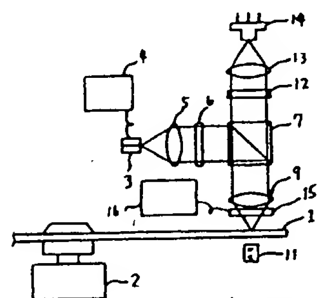

Figure 2

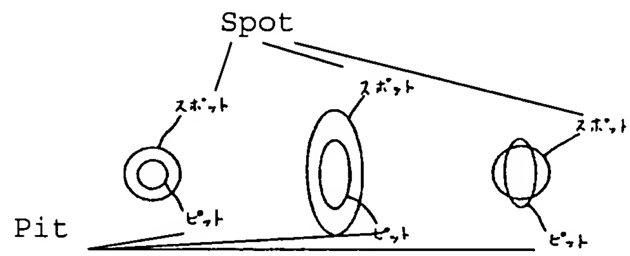


Figure 4 Figure 5 Figure

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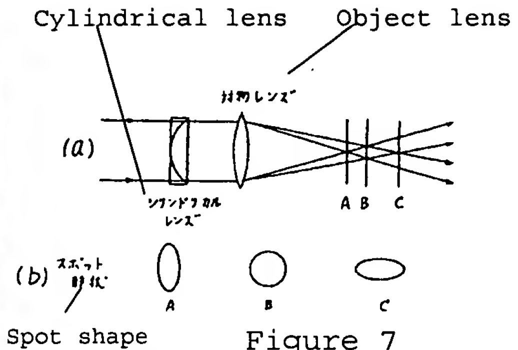


Figure 7

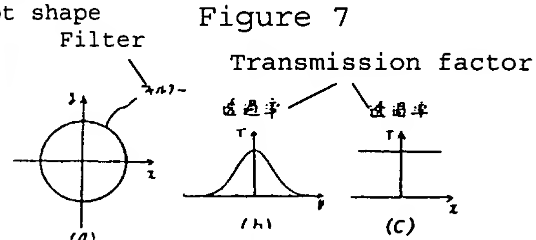


Figure 8

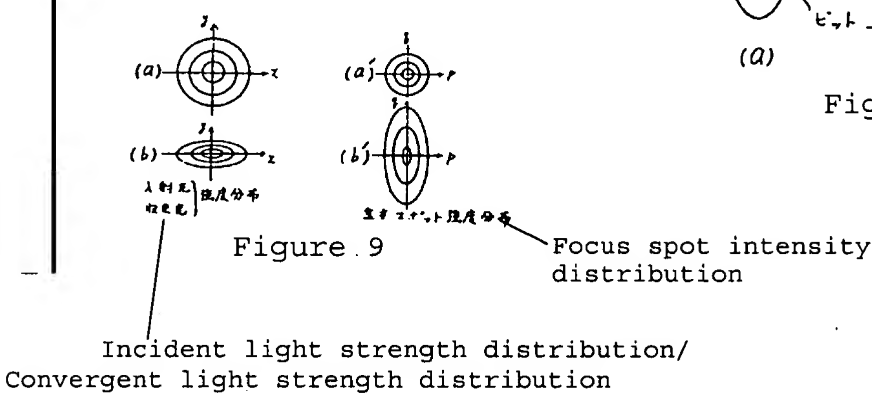


Figure 9

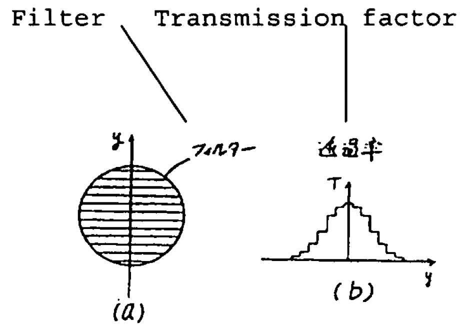


Figure 10

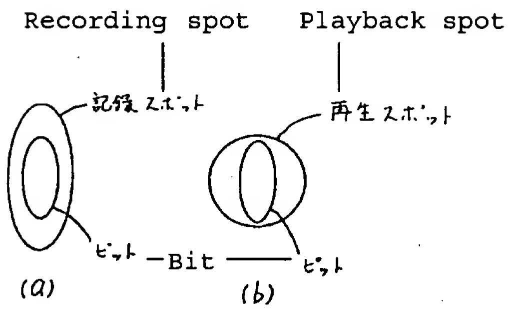


Figure 11